CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-177

Lenwood Fault, Old Woman Springs Fault, and Silver Reef Fault, San Bernardino County

by
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INTRODUCTION

The Lenwood, Old Woman Springs, and Silver Reef faults, which are located in southwestern San Bernardino County, have been examined as part of CDMG's Fault Evaluation Program. Portions of these faults have been mapped by previous workers (Bowen, 1954; Bull, 1978; Dibblee, 1960a, 1960b, 1964a, 1964b, 1964c, 1967a, 1967b, 1970; Dokka, 1980; Gardner, 1940; Morton and others, 1980; Sadler, 1982; Shreve, 1968; Vaughan, 1922), and several of these workers provide evidence of Holocene or latest Pleistocene fault rupture. Based on the available reports, and air photo evidence and field observations that are described below, several traces of the Lenwood and Old Woman Springs faults meet the requirements of "sufficiently active and well-defined" necessary for zoning under the Alquist-Priolo Special Studies Zones Act (Hart, 1985, p. 5-6) and are recommended for zoning. The inferred connection of the Lenwood and Lockhart faults (Page and Moyle, 1960) could not be verified as a surface feature, and is not recommended for zoning. The northwestern extension of the Silver Reef fault (Dibblee, 1964a) locally is concealed by a massive landslide that has been ^{14}C dated as being 17,400 $\pm$ 550 years old; therefore the Silver Reef fault is not sufficiently active to warrant zoning.

SUMMARY OF AVAILABLE DATA

Lenwood fault

The Lenwood fault is one of a series of subparallel, northwest-trending, right-lateral, strike-slip faults in the western Mojave Desert. Figure 1 (from Jennings, 1975) shows the Lenwood fault in relation to other faults in the region, several of which are examined in other FER's. Figure 2 shows the U.S.G.S. topographic quadrangles traversed by the Lenwood fault. The Lenwood fault was mapped in its entirety and named by Dibblee (1960a, 1964b, 1964c, 1967b, 1970), and is shown in detail in Figure 3. Discontinuous segments of the fault are included in small-scale maps by Bowen (1954), Gardner (1940), and Vaughan (1922); their mapping is more generalized than Dibblee's, and their traces are not shown in Figure 3. Dokka (1980) also included a portion of the Stoddard Valley segment of the Lenwood fault in his thesis map. His mapping is similar to Dibblee (1970), below. Thompson (1929) did not show the fault on his small-scale reconnaissance map.

Dibblee shows the Lenwood fault to have a total length of approximately 70 km (44 miles), trending northwestward from the San Bernardino Mountains to the Mojave River at Lenwood. He interprets the fault to be vertical in cross-section, with various senses of vertical offset (Dibblee, 1960a, 1967b, 1970). Right-lateral strike-slip displacement is indicated locally in the

Daggett, Ord Mountains, and Old Woman Springs 15' quadrangles, with inferred right-slip shown in the Barstow 15' quadrangle (see Figure 3). The youngest unit clearly shown to be offset by the Lenwood fault is Holocene alluvium in sec. 23 in the Rodman Mountains quadrangle (see Figure 3); however, this may be a drafting error. Where bedrock units or Pleistocene alluvium are truncated by faulting, Dibblee generally shows the unit to be faulted against young alluvium (for example, at Soggy Lake, Lucerne Valley, and Tyler Valley). Elsewhere, the fault is shown as concealed by young alluvium of Holocene or undifferentiated Holocene and Pleistocene age.

Page and Moyle (1960, Figure 2) show the Lenwood and Lockhart faults to be connected by a northwest-trending fault that has a length of approximately 25 km (16 miles; see Figure 1 of this report). This connecting fault offsets Pleistocene alluvium but not Holocene alluvium. The connecting fault, which is not shown in Figure 3, is not verified by Dibblee (1960a, 1960b, 1968), although Page and Moyle's map is based upon a generalization of Dibblee's then-unpublished mapping of that area.

Sadler (1981, 1982) mapped portions of twelve 7.5' quadrangles in the northeast San Bernardino Mountains. His structural geologic map of the Old Woman Springs 7.5' quadrangle shows a discontinuous, northwest-trending fault south of Soggy Lake, similar to the mapping of Morton and others (1980). The fault is shown to separate "relict" (Pleistocene?) and "active" (Holocene) alluvial fan surfaces.

Morton and others (1980) used black-and-white, low-sun-angle air photos to produce their photoreconnaissance map of fault-related features along the Lenwood fault (see Figure 4). Their annotated strip map shows alignments of scarps and tonals in younger and older alluvium, and alignments of saddles, linear trenches and drainages, closed depressions, etc., in bedrock along the general trend of the fault as mapped by Dibblee (see above). However, they did not field-check the geomorphic features, nor do they discuss recency of faulting. Their data are plotted on 1:24,000-and 1:62,500-scale maps, and comprise the single most-important source of information on recently-active traces of the Lenwood fault. Most of the fault-related features shown by Morton and others were verified by photo-inspection and field-inspection during this study (see Figure 4 and p. 5-7, below). Annotations such as "Scarps appear to cut youngest alluvium" suggest that the fault has been active in Holocene time.

In January 1973 D.M. Morton (U.S.G.S.) and C.H. Gray (C.D.M.G.) investigated reports of structural damage to 6 homes in Lenwood (see Figure 4, Locations 2 and 3). The damage consisted of cracks (less than 2 cm wide) in the walls of these homes (C. Gray, 1986, written comm.), although D.M. Morton (1986, pers. comm.) stated that one of the homes on Cheryl Street was skewed "2 or 3 inches" off of its slab foundation and had to be torn down. The alignment of damaged homes shown on the map provided by Gray has a significantly more northerly trend than the shallow linear swale shown by Morton and others (Figure 4).

Bull (1978) includes a reconnaissance appraisal of Quaternary tectonic activity along the Lenwood fault. He uses five differential equations, which interrelate uplift, erosion, and deposition along streams that cross mountain fronts, to divide major mountain ranges along the fault into one of three classes of terrain. According to Bull (1978, p. 33), "Class 1 ['active'] fronts occur in highly active tectonic settings that are generally characterized by active folding and/or faulting during the Holocene as well as the Pleistocene. Class 2 ['slightly active'] faulted mountain fronts generally have ruptured Pleistocene, but not Holocene, geomorphic surfaces. *** Class 3 ['inactive'] mountain fronts, by definition, have been tectonically inactive during the Quaternary." Of the four mountain fronts along the Lenwood fault that were analyzed by Bull (p. 183), two are classified as "active", and two are classified as "slightly active". Alternating segments of the Lenwood fault are classified as "active" or "slightly active" (Bull, 1978, p. 73-74).

Evidence of Holocene rupture along the Lenwood fault, which are cited by Bull and noted on Figure 4, include a low scarp (0.5 - 0.7 m high) in Holocene playa sediments at Soggy Lake (p. 111, 113-116), and an offset Holocene alluvial fan in a small valley at the SW corner of sec. 11, T. 8 N., R. 1 W. (p. 106). Rockfalls, presumably due to large earthquakes on the fault, also were noted (p. 118, 121-122).

In his summary and conclusions (p. 161), Bull noted the following information:

> "Holocene and latest Pleistocene geomorphic surfaces can be differentiated because of climate-controlled changes in the modes of operation of the arid fluvial systems. Below altitudes of about 1,200 m, the latest Pleistocene surfaces are characterized by well sorted gravels, smooth, brownish-black desert pavements, argillic B soil horizons, and depths of C_{ca} horizons of about 0.3 m. Holocene surfaces consist of poorly sorted bouldery gravel, bar-and-swale topography, brown varnish, a lack of argillic soil horizons, and depths to C_{ca} horizons of about 0.1m. Locally, basalt flows and playas have been ruptured during the Holocene, and earthquake-caused rockfalls onto Pleistocene and Holocene geomorphic surfaces are common next to fault scarps, but are absent on nearby steep slopes that are not adjacent to active faults."

His criteria for distinguishing between latest Pleistocene and Holocene surfaces were extensively used by me during my field inspections for this report (see "Air Photo Interpretations and Field Observations", below).

Various workers have estimated the amount of lateral displacement along the Lenwood fault. Garfunkel (1974) calculates that 15-20 km of right-lateral displacement has occurred since Miocene time, based upon locations of "offset" Paleozoic marine sedimentary rocks. Miller and Morton (1980, p. 21-22) state that apparent left-lateral fault displacement of up to 10 km is suggested by displacements of projected apparent-age contours, but the contour projections could be relocated up to 2 km in either direction along the fault without causing a contour spacing different from that found in other areas of their map. Miller and Morton note that the displacements of apparent-age contours along the Helendale fault to the west also do not agree with geologic evidence, and they state that the most plausible explanation for lack of agreement on both faults is that there are components of vertical movement along each fault. Dokka (1983, p. 307) calculates that right-lateral displacement along the Lenwood fault is no greater than 1.5 to 3.0 km. His estimate is based on measurements of an offset, high-angle, southern margin of an early Miocene detachment fault terrane.

Old Woman Springs fault

The Old Woman Springs fault lies west of the Lenwood fault and east of Lucerne Valley (see Figures 1 and 2). The Old Woman Springs fault was first mapped by Vaughan (1922), who shows the segment from Highway 247 south to the San Bernardino Mountains on his small-scale reconnaissance map. More-recent, larger-scale mapping by Dibblee (1964a, 1964b, 1967b), who named the fault, includes the segment mapped by Vaughan, and also shows the fault extending from Highway 247 northward along the west margin of Fry Valley, to connect with the Lenwood fault (see Figure 3). The total length of the fault as mapped by Dibblee is 37 km (23 miles), and the strike of the fault changes progressively, from due West at its southern end to nearly due North at its junction with the Lenwood fault. The segment of the fault along the base of the San Bernardino Mountains was not evaluated in this report. This segment is currently being evaluated as FER-182 (W.A. Bryant, p.c., 1986).

In the Lucerne Valley and Ord Mountains 15' quadrangles (Dibblee, 1964a and 1964b, respectively), the northern end of the fault is shown to juxtapose Mesozoic granitic rocks against Holocene alluvium, but this segment locally is concealed by youngest alluvium (see Figure 3). In the Old Woman Springs 15' quadrangle (Dibblee, 1967b), the fault is shown to extend southward from the NW corner of the quadrangle to Highway 247 as an inferred structure that is concealed by young alluvium of undifferentiated Holocene and Pleistocene age. As seen in Figure 3, the Old Woman Springs fault is mapped as a well-defined surface feature from Highway 247 southeastward to the mountains. This segment of the fault offsets Tertiary basalt and Pleistocene-age older fan deposits, and juxtaposes these units against younger alluvium (undifferentiated Holocene and Pleistocene). Younger alluvium is shown to be faulted near Cottonwood Springs. Near the southeast end of this segment, the fault locally is concealed by young alluvium and fan deposits. A short, south-trending branch fault splays off from the main trace near Cottonwood Spring. Dibblee (1967b) shows this branch fault locally to offset and be concealed by older fan deposits. At its south end, the branch fault separates older and younger fan deposits. In cross section, both faults are shown to be vertical. Sense of displacement is given only for this southern segment of the Old Woman Springs fault. Both the main trace and branch fault are interpreted by Dibblee to have right-oblique slip, and a large horst has been forced upward between the two strands near Old Woman Springs (see Figure 3).

Sadler (1982) also mapped the segment of the Old Woman Springs fault south of Highway 247 during his study of the structural geology of the northeastern San Bernardino Mountains. The main trace of the Old Woman Springs fault is shown by Sadler in approximately the same location as by Morton and others (1980; below) and by Dibblee (1967b); therefore his fault traces are not shown on Figures 3 or 5. He shows the fault locally to separate young alluvium and Tertiary sandstone near Cottonwood Spring.

Morton and others (1980) produced a photoreconnaissance strip map of young-looking fault features for the Old Woman Springs fault similar to their map of the Lenwood fault (see p. 2 above, and Figure 5). Although not field-checked by the authors, their map is probably the most important single source of information on recently-active traces of this fault. As shown in Figure 5, the active trace of the Old Woman Springs fault can be followed as an alignment of scarps, drainages, and other features along the general trend shown by Dibblee in Figure 3. Annotations such as "Relatively young-looking ... scarp in alluvium and older alluvium", suggest that the fault has been active in Holocene time.

In Bull's study of the Mojave Desert (described above, on p. 2-3), he notes evidence of two Holocene events on the Old Woman Springs fault that ruptured young alluvium 2 km northwest of Old Woman Springs (Bull, 1978, p. 106 - 109; see Figure 5). The north end of the fault, and both the branch fault and the main trace south of Highway 247, are classified as "active" by Bull (p. 74). Dibblee's concealed and inferred segment north of Highway 247 is classified as "inactive", although the Lenwood branch fault, with which it connects to the north, is classified as "active".

Silver Reef fault

The Silver Reef fault (Shreve, 1968) is a northwest-trending fault on the western side of Old Woman Peak (see Figures 1 and 2). Vaughan (1922) mapped the feature as a unit contact. Dibblee (1964a, 1967b) also mapped the fault (which is unnamed on his maps). He extended it northwestward as an concealed feature beneath the Blackhawk landslide, and southeastward as a locally-concealed fault to the San Bernardino Mountains (see Figure 3). [The junction of the Silver Reef fault and North Frontal fault zone is not examined in this report; see FER-182.] He shows the fault to be relatively short (13 km; 8 miles), have right-lateral strike-slip displacement, and to be nearly vertical in cross section. Total displacement is not indicated by Dibblee, although a large body of gneiss may be offset horizontally as much as 1 km. Shreve (1968, p. 24) notes northeast-facing scarps with heights of 10 feet (3m) in Pleistocene(?) fanglomerate east of the Akron Silver Reef mine, and also lower, east-facing scarps in bedrock west of Old Woman Peak (Figure 5). Dibblee shows the fault locally to offset Pleistocene alluvium, and to offset and be concealed by alluvium of undifferentiated Holocene and Pleistocene age. He also shows a segment of the fault to be concealed by the Blackhawk landslide. The age of the landslide, based upon ^{14}C measurements by Stout (1982), is 17,400 ± 550 y.B.P. Bull (1979, p. 74) classifies this fault as "slightly active".

Several faults and master joints along the Silver Reef fault are shown by Sadler (1982) in his structural geology maps of the Cougar Buttes, Old Woman Springs, and Rattlesnake Canyon 7.5' quadrangles. Sadler does not show the Silver Reef fault offsetting the Blackhawk landslide or post-landslide alluvium to the northwest of the slide.

AIR PHOTO INTERPRETATION AND FIELD OBSERVATIONS

My air photo interpretations and field observations for the Lenwood fault are included in Figure 4, which is a photoreconnaissance map of young-looking fault features along the Lenwood fault by Morton and others (1980, sheet 2). I used their strip map as a base for my data because it shows apparently fault-related geomorphic features on a suitably-scaled topographic map. My data for the Old Woman Springs fault and Silver Reef fault are shown on Figure 5, which also includes all data of Morton and others (1980, sheet 7) for the Old Woman Springs fault. In general, the features noted by Morton and others were verified during this study, and are accurately located. However, some features shown by them were not verified.

Two sets of black-and-white air photos were available to me: U.S.B.L.M., 1977, series CA 93-77; and U.S.B.L.M., 1978, series CAHD-77. The low-sun-angle air photos used by Morton and others were not available. Field inspections of the Lenwood and Old Woman Springs faults were made by me on January 16 and March 3-7, 1986. Due to time constraints, the Silver Reef fault was not field-checked. Earl Hart and William Bryant, C.D.M.G., assisted me in field work on January 16. Earl Hart assisted in air photo interpretation.

Lenwood fault

The Lenwood fault is generally well-defined in discontinuous segments from just east of Barstow Road (Highway 247) in Stoddard Valley, southeastward to Stony Ridge Road, northeast of Old Woman Springs (see Figure 4). Recently-active traces can be followed as alignments of scarps, linear drainages, sidehill benches, breaks-in-slope, shutter ridges, closed depressions, deflected drainages, and offset alluvial fans. Southeast of Stony Ridge Road, the fault is largely concealed by young alluvium, although its position near Highway 247 is suggested by an en echelon alignment of knolls, scarps, and weak tonals in late Quaternary alluvium (see Figure 4). Geomorphic evidence of recent faulting is rather discontinuous from near Barstow Road northwestward to the vicinity of Lenwood (Figure 4). Due to time constraints, this segment of the Lenwood fault was not extensively field-checked. Reported evidence of possible fault creep in Lenwood (D. Morton, U.S.G.S., 1986, pers. comm.; C. Gray, C.D.M.G., 1986, written comm.) was examined in the field, but could not be verified as being fault-related (see Figure 4, Locations 2-3).

The probability that the Lenwood fault has been active during Holocene time is strongly suggested by the abundance of relatively fresh, ephemeral features along various segments of the fault. The most notable features are the linear scarps and tonals in Holocene and latest Pleistocene alluvium (see Figure 4, Locations 9, 13, 27, and 31), and the closed depressions and sidehill benches (Locations 8, 9, 19, 20, 23, 26, and 31). The existence of shutter ridges and offset drainages, fans, and valleys along the fault (Locations 13, 14, 19 and 31) clearly indicate a dominant element of right-lateral strike-slip displacement, but scarps and depressions suggest that components of dip-slip are locally important.

Evidence of Holocene surface rupture along the Lenwood fault is located in sec. 10, T. 8 N., R. 1 W. (S.B.B.M), where a large closed depression (graben) has been formed by the main fault and a westerly branch fault (see Figure 4, Locations 8-9). Here, the main trace is a well-defined, southwest-facing scarp, up to 7 meters high, in an alluvial fan of latest Pleistocene to early Holocene age. Holocene alluvium abuts the scarp, and may be faulted. Bull (1979, p. 106) describes a 1.0 to 1.5 meter-high scarp in mid- to late Holocene alluvium to the southeast (not examined in the field). Northwest of the valley, the main trace is well-defined as an alignment of linear drainages, scarps, and sidehill benches in bedrock. This series of features also aligns with the scarp in alluvium described above. The fault locally is covered with Holocene alluvium and colluvium in the linear drainage. At the southeast end of the valley (Location 10) is a large rock that Bull (1978, p. 122) contends fell from the ridge to the east during an earthquake on an adjacent fault.

Evidence of latest Pleistocene or Holocene faulting is found in a small, unnamed valley (closed depression) in sec. 35, T. 7 N., R. 1 E., west of Tyler Valley (see Figure 4, Location 19). This is where Dibblee (1964b) shows faulted Holocene alluvium (Figure 3). At the northwest end of this valley, faulting has formed a northeast-facing scarp, several meters high, in bedrock and colluvium. This scarp has blocked the valley's drainage, forming a small (presently dry) lake. Headward erosion along the main drainage has partially cut through the scarp. The lake probably has been dry since the local climate became more arid, which King (1976, p. 187-189) estimates to have occurred approximately 7,800 years B.P.

Old Woman Springs fault

The main trace of the Old Woman Springs fault is a well-defined surface feature, both on the air photos and in the field, from the SW 1/4 sec. 24, T. 4 N., R. 2 E., southeastward through Cottonwood and Old Woman Springs to the SW 1/4 sec. 4, T. 3 N., R. 3 E. This segment of the fault can be followed as an alignment of northeast-facing scarps, offset ridges, linear drainages, sidehill benches, and right-laterally-deflected drainages, in both bedrock and alluvium (see Figure 5). My interpretations are in general agreement with those of Morton and others (1980). The faulted alluvium is classified as undifferentiated Holocene and Pleistocene by Dibblee (1967b), although Bull (1978, p. 106-109) noted an offset, gravel-capped sag pond in Holocene sediments near Cottonwood Spring (Figure 5). The main fault plane is exposed at an unnamed spring in sec. 31, approximately 700 meters (.45 miles) northwest of Old Woman Springs (Figure 5, Location 39). The vertical fault trends N. 44° W. and has weak horizontal slickensides in the fault gouge.

Southeast of sec. 4, the active trace is more difficult to follow as a surface feature. However, a tonal in Holocene alluvium aligns with discontinuous, northeast-facing scarps, a northwest-trending shuttter ridge in Pleistocene alluvium, and three deflected drainages (see Figure 5).

Northward from the SW 1/4 sec. 13, T. 4 N., R. 2 E., to sec. 22, T. 5 N., R. 2 E., the fault generally cannot be followed as a surface feature. This fault segment is shown by Dibblee (1964b) as concealed by the undifferentiated Holocene and Pleistocene alluvium. A prominent, east-facing, bedrock-alluvium contact in sec. 22, also noted by Morton and others (1980), is shown by Dibblee to be a fault contact between bedrock and Holocene alluvium. North of sec. 22, in sec. 10 and 15, Dibblee (1964a, 1964b) again shows the fault separating bedrock and Holocene alluvium before it joins the Lenwood fault. Although Bull (1978, p. 74) classifies this northern segment of the fault as "active", I saw no permissive air photo evidence of recent strike-slip displacement, nor were any geomorphic features noted by Morton and others (see Figure 5). Entrenched, non-deflected drainages that cross the fault may indicate that vertical displacement is predominant along the northern segment.

Silver Reef fault

The Silver Reef fault can be followed on the air photos from the S 1/2 sec. 2, T. 3 N., R. 2 E., northwestward to the NE 1/4 sec. 28, T. 4 N., R. 2 E., as an alignment of moderately well-defined features in bedrock, and in alluvium of Pleistocene and undifferentiated Holocene and Pleistocene age (see Figure 5). In sec. 2, the fault has formed discontinuous, northeast-facing scarps in

Pleistocene alluvium, against which is deposited the younger, undifferentiated alluvium. To the northwest, in sec. 28, fault movement in the younger alluvium has formed a tonal and northeast-facing scarp. Northwest of the tonal, in sec. 20, 21, and 28, the Silver Reef fault is concealed by the Blackhawk landslide (dated at 17,400 ± 550 y.B.P.; Stout, 1982) and by a post-landslide alluvial fan. However, no air photo evidence of strike-slip faulting was seen along the projected trace of the Silver Reef fault. Due to time constraints, the fault was not field checked. The fault was not evaluated southeast of Arrastre Creek (see FER-182, currently being prepared by W.A. Bryant).

SEISMICITY

An examination of 'A' and 'B' quality epicenter locations for the period 1969-1984 (CalTech, 1985) shows that there is some seismic activity on or near the Lenwood fault (especially near the southeast end of the fault), and on the Old Woman Springs fault. No seismicity was recorded for the Silver Reef fault, or along the inferred connection of the Lenwood and Lockhart faults (see Figure 6).

CONCLUSIONS

1. The Lenwood fault is a major, right-lateral, strike-slip fault which extends 70 km (44 miles) northwestward from the San Bernardino Mountains to the Mojave River at Lenwood. The fault is one of the series of subparallel, closely-spaced faults in the central Mojave Desert (Figure 1). The proximity of the concealed southeast end of the Lenwood fault to the San Bernardino Mountains suggests a complex intersection of this fault and the Old Woman Springs fault with the west-trending reverse faults along the north flank of the mountain range. The northwest end of the Lenwood fault is inferred by Page and Moyle (1960) to extend 25 km (16 miles) further to connect with the Lockhart fault, but this hypothesis is not substantiated by Dibblee (1960a, 1960b, 1968), nor by my air photo interpretation. Previous workers do not agree on total displacement along the Lenwood fault, with extimates of post-Miocene displacement ranging from 1.5 - 3km (Dokka, 1983) up to 15-20 km (Garfunkel, 1974).

The active trace of the Lenwood fault can be followed as a discontinuous surface feature from the vicinity of Barstow Road (Highway 247) in Stoddard Valley southeastward to Stony Ridge Road, near Old Woman Springs. This segment of the fault generally is well-defined by discontinous alignments of geomorphic features in alluvium and bedrock, such as scarps, linear drainages, shutter ridges, breaks-in-slope, and deflected drainages. Scarps in Holocene alluvium are located at Soggy Lake, and in an unnamed valley northeast of Stoddard Valley. Southeast of Stony Ridge Road to Highway 247, the Lenwood fault is largely concealed by young alluvium, although its position may be indicated by an alignment of widely-spaced knolls in Pleistocene alluvium. Southward from Highway 247, several enechelon scarps in Pleistocene alluvium show the fault's position. Northwest of Barstow Road to Interstate Highway 15, evidence of surface rupture on the active trace is more subtle and discontinuous. Reported evidence of fault creep in Lenwood (D. Morton, personal comm.; C. Gray, written comm.) was field-checked by me, but it could not be confirmed as being fault-related.

2. The Old Woman Springs fault is a major fault located between the Lenwood fault and Lucerne Valley (see Figure 1). The Old Woman Springs fault appears to branch off of the Lenwood fault and extends southeastward to the San Bernardino Mountains, where it changes from a right-lateral strike-slip fault to an east-trending, south-dipping reverse fault (Figure 3). Total length of the fault is 37 km (23 miles), but the east-trending segment was not evaluated in this report.

The main fault segment south of sec. 13, T. 4 N., R. 2 E., is the most active and best-defined segment. The fault can be followed as an alignment of scarps in bedrock and Holocene alluvium, linear drainages, offset ridges, sidehill benches, and deflected drainages. Strike-slip displacement is indicated by the linearity of the fault trace, and by horizontal slickensides in fault gouge exposed at one location. Northward from sec. 13, T. 4 N., R. 2 E., to sec. 22, T. 5 N., R. 2 E., the fault cannot be followed as a surface feature, and Dibblee (1967b) shows this segment as inferred and concealed. Northward from sec. 22 to near its apparent junction with the Lenwood fault, the Old Woman Springs fault can be followed as a linear break-in-slope between Holocene alluvium and bedrock, but there is no permissive evidence of recent right-lateral fault rupture. Entrenched, non-deflected drainages that cross the fault near its north end indicate that this segment has not been recently active as a strike-slip fault, but may have vertical displacement.

3. The Silver Reef fault is a minor, northwest-trending fault with a total length of 13 km (8 miles). The fault is subparallel to and a few kilometers west of the Old Woman Springs fault (Figure 1). Dibblee (1967b) shows the fault to have right-lateral, strike-slip displacement, but several northeast-facing scarps in Pleistocene alluvium are crossed by entrenched drainages (Figure 5), indicating that vertical displacement may be important locally. Although not indicated by Dibblee or Shreve (1968), total displacement is probably less than 1 km. The fault locally is shown by Dibblee to offset and be concealed by alluvium of undifferentiated Holocene and Pleistocene age. The northwest end of the fault is concealed by the Blackhawk landslide mass, which Stout (1982) estimates to be 17,400 ± 550 years old. The southeastern segment of the fault and its junction with the North Frontal fault zone were not examined in this report. No air photo evidence of strike-slip faulting was seen in the landslide debris, and the fault was not field-checked.

RECOMMENDATIONS

The Lenwood fault southeast of Interstate Highway 15 generally meets the necessary requirements of "sufficiently active and well-defined", and should be zoned as shown on Figures 7a and 7b. References cited should be Morton and others (1980) and this report for fault location, and Bull (1978) and this report for fault recency. Dibblee (1960a, 1964b, 1964c, 1967b, 1970) should also be cited for confirmation, although his specific traces were not used. The main trace of the Old Woman Springs fault southeastward from the SW 1/4 sec. 13, T. 4 N., R. 2 E., meets the necessary criteria and should be zoned as shown in Figure 7b. References cited should be Morton and others (1980) and this report for fault location, and Bull (1978) and this report for fault recency. Dibblee (1964a, 1964b, 1967b) should also be cited for confirmation, although his specific traces were not used. The remaining segments of the

Lenwood and Old Woman Springs faults do not meet the requirements and should not be zoned. The Silver Reef fault northwest of Arrastre Creek is not sufficiently active to warrant zoning.*

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I have reviewed this report and aerial photographs and concur with the recommendations.
Earl W. Hart
6/16/86

* 9/16/86 - Based on air photo and field data described in his FER-192, W.A. Bryant (CDMG) is recommending that the Silver Reef fault be zoned. After reviewing his data (Bryant, 1986, p.c.) I agree that the fault should be zoned northwestward to the Blackhawk landslide.

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EARTHQUAKES M1.0 OR GREATER

CIT 1969-1984 AB QUALITY ONLY

SAN BERNARDINO SHEET

TRANSVERSE MERCATOR PROJECTION

SCALE = 1/250000

MAGNITUDE

+ ..... 1.0 TO 1.9
+ ..... 2.0 TO 2.9
+ ..... 3.0 TO 3.9
+ ..... 4.0 TO 4.9
+ ..... 5.0 TO 5.9
+ ..... 6.0 TO 6.9

Scale 1:250,000

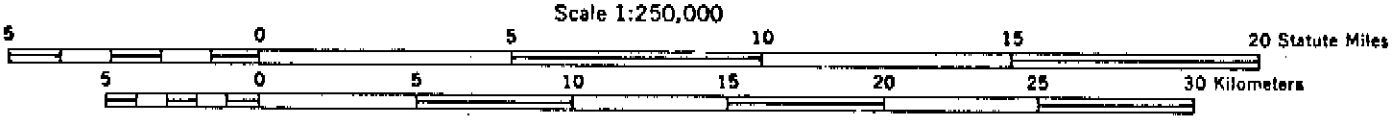


Figure 6 to FER-177: Seismicity map for vicinity of Lenwood, Old Woman Springs, and Silver Reef faults, San Bernardino County, for the period 1969-1984 (CalTech, 1985).

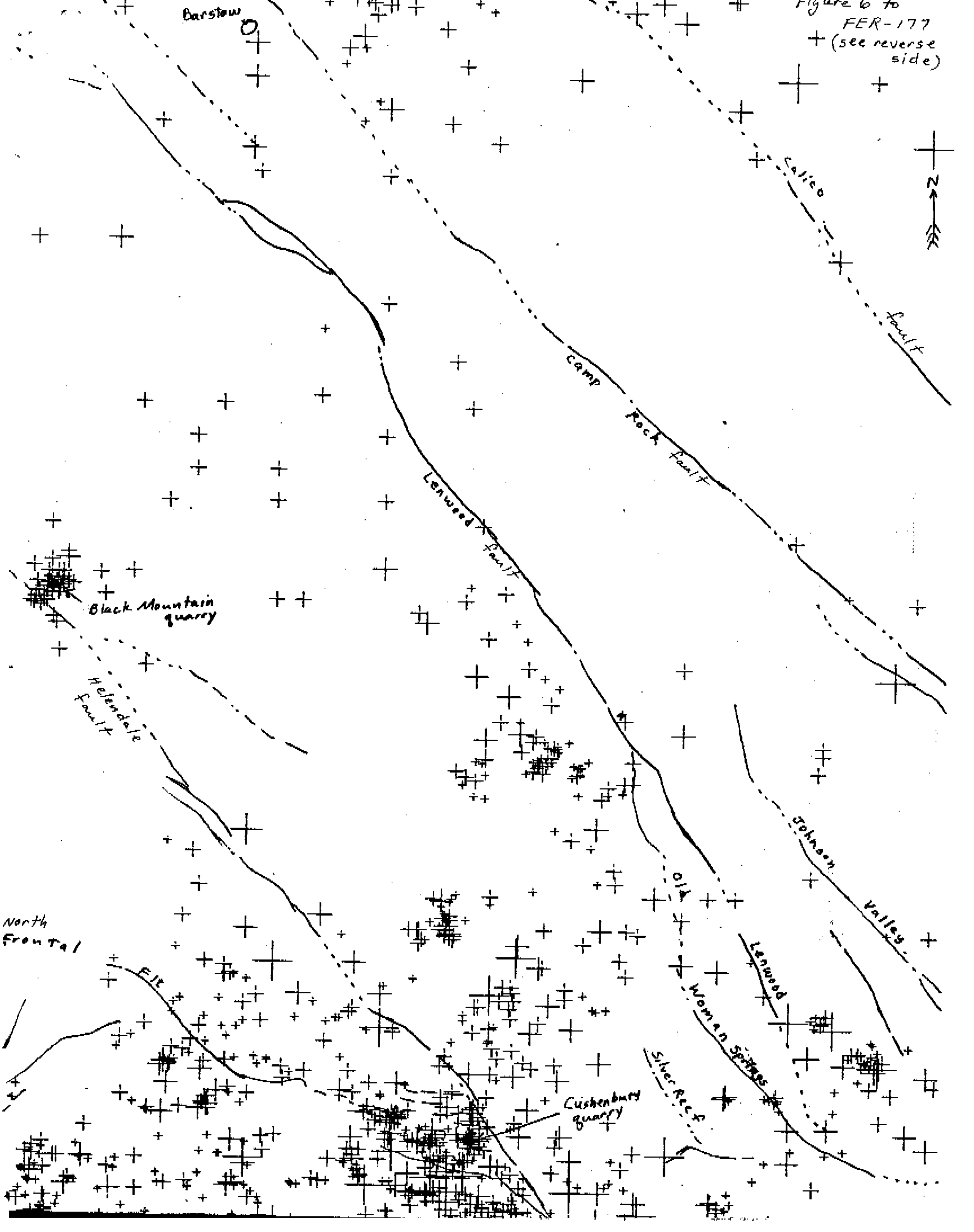
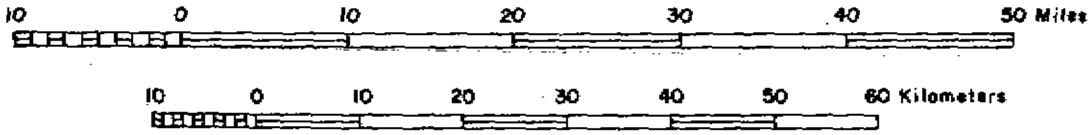


Figure 6 to
FER-177
(see reverse side)
Barstow
N
Calico fault
Camp Rock fault
Lenwood fault
Black Mountain quarry
Helendale fault
Johnson Valley
Old Woman Springs
Lenwood
Silver Reef
North Frontal
Flt
Cushenbury quarry


10 0 10 20 30 40 50 Miles
10 0 10 20 30 40 50 60 Kilometers

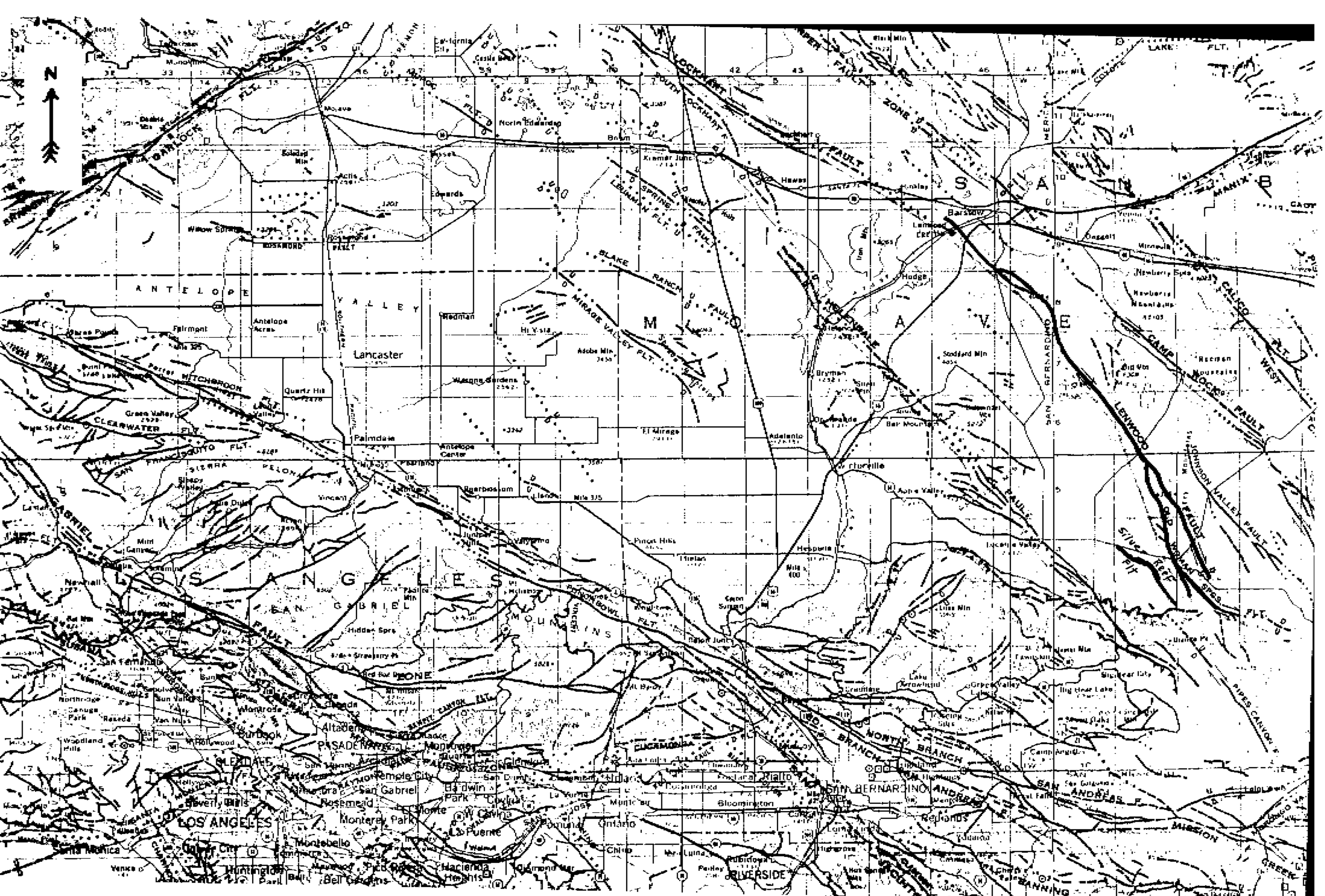


Figure 1 to FER-177: Regional fault map showing locations of Lenwood fault, Old Woman Springs fault, and Silver Reef fault, San Bernardino County. Base map from Jennings (1975).

Map scale on reverse side.

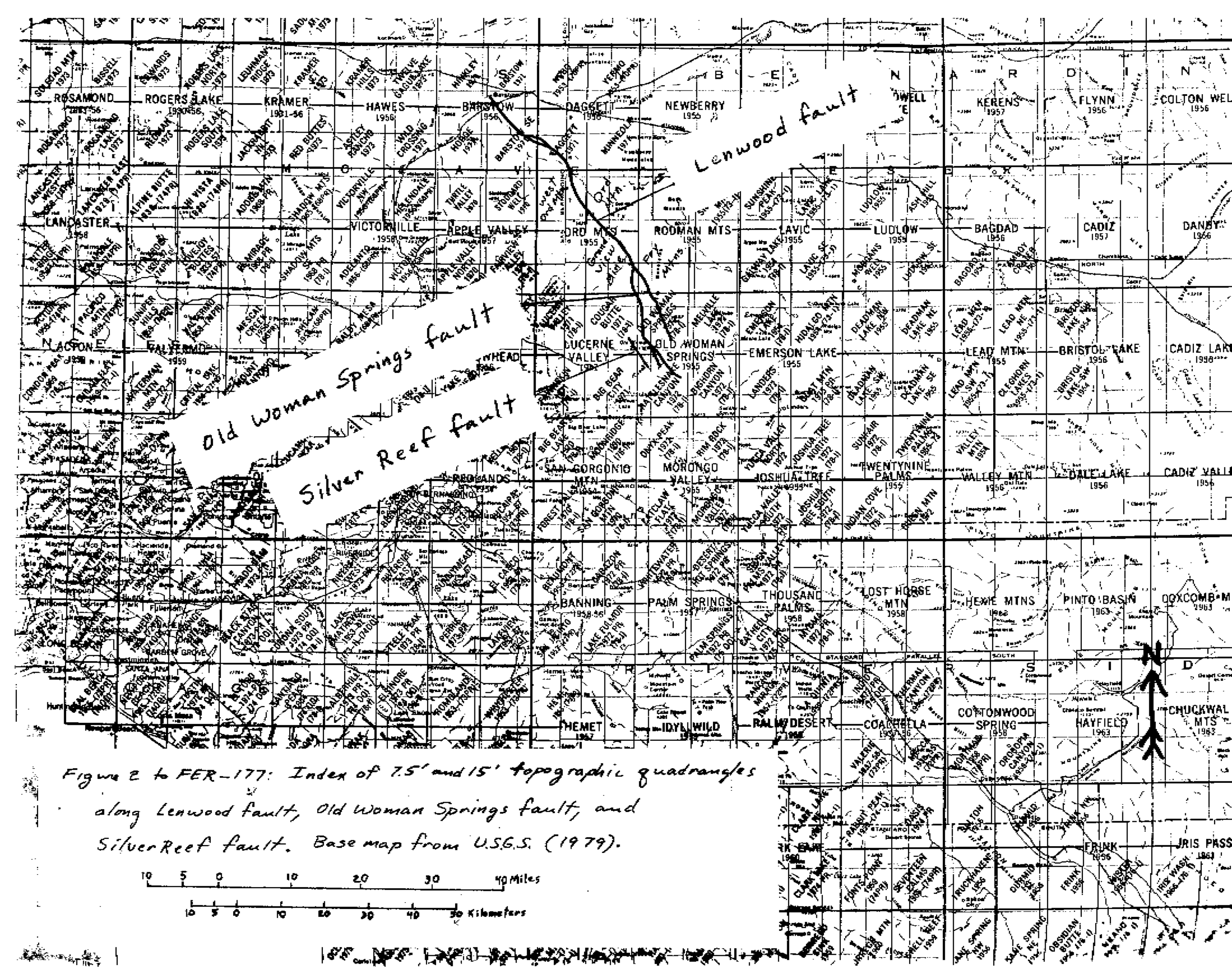


Figure 2 to FER-177: Index of 7.5' and 15' topographic quadrangles along Lenwood fault, Old Woman Springs fault, and Silver Reef fault. Base map from U.S.G.S. (1979).